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Effects of extreme meteorology in Seville during the 18th century: defense mechanisms against droughts and floods of the Guadalquivir

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Water risk
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INTRODUCTION

During the 18th century, the city of Seville (37.38 N; 5.97 W) experienced frequent effects from extreme meteorological events. The main characteristic of rainfall in the southwest of the Iberian Peninsula is inter-annual variability; multi-year periods of drought alternated with periods of intense and prolonged rains and flooding. The city of Seville is located on a low-lying alluvial plain, which carries the risk of urban flooding. For this reason, in the 18th century, the medieval walls were preserved as the main defense system against the overflowing of the Guadalquivir River. From documentary sources, we reconstruct the effects of the re-curring meteorological phenomena on the urban and social climate of the time.

STUDY BASES

A. The climatic context. Meteorological irregularity is one of the fundamental characteristics of the Mediterranean climate with Atlantic influence in the southwest Iberian Peninsula. The 18th century was heavily affected by the period of the Little Ice Age (PEH), which spans from the beginning of the 16th century to the beginning of the 19th century. This time is characterized by the start of natural variability of the climate in Europe, which includes a decrease in temperature and an increase in the irregularity of interannual rainfall. Between 1645 and 1715, there was a decrease in solar activity, re-ferred to as the Maunder Minimum, which possibly had an influence on the climate evolution at the

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time. Furthermore, at the end of the 18th century, a new period of decreased solar activity began, the Dalton minimum (1790 to 1820), which may have also contributed to changes in the climate system. Also, the frequency and intensity of volcanic ash emissions may have contributed to the thermometric variability of the PEH due to the reflectivity of volcanic aerosols in the atmosphere.

B. Urban conditions: Seville has historically been protected by walls for centuries. The city is also surrounded by the Guadalquivir River to the west, and the Tagarete and Tamarguillo tributaries to the east. The Roman city (figure 1) occupied elevated natural terraces protected from flooding, next to a secondary branch of the river. In the 12th century, the city expanded so that the late medieval wall was formed by a 6km long perimeter fence with fourteen gates and several shutters. This wall remained until the middle of the 19th century. Since the 16th century, the medieval wall has served as the city's main protection against river flooding. However, the suburbs located outside the walls without protection suffered disastrous consequences during periods of flooding. A unique element of Seville is the drainage system, "husillos" with internal regulation in cases of river overflow. To better understand the function of these structures, the map of Seville with a walled enclosure and the corresponding gates is included in this article.

DOCUMENTARY SOURCES

The documentary sources used have been diverse and with different approaches. "Critical history of the floods or great avenues of the Guadalquivir in Seville since its reconquest today", the documentary compilation made by Francisco de Borja Palomo (1778). It is mainly aimed at describing the impacts of river overflows, both in urban and social aspects, rather than at exposing the meteorological conditions that caused them. Regia Sociedad Hispalense, a scientific academy where dissertations related to the meteorology and climate of Seville are preserved. These dissertations offer insights into the causes of Guadalquivir floods and recommendations to mitigate their disastrous effects. Prayers of religious intercession either to start or stop rain, among which the series highlights the transfer of the image of the Virgen del Rocío from her hermitage in Doñana. - Collection of ecclesiastical tithe on agricultural production in areas of the archdiocese, as well as reports from administrators of manor houses detailing weather conditions that may have affected agricultural production, either positively or negatively.

METHODOLOGY

In our methodology, we relied on information gathered from various historical documentary sources concerning extreme weather phenomena and their urban and social impacts. These sources typically offer descriptive accounts that are subjective and lack uniformity in assessing and qualifying events. To address this issue, we established criteria to facilitate the comparative classification of impacts. We found it necessary to translate the qualitative descriptions of observed effects into a standardized ordinal scale. As a result, we developed the annual RH water risk index, which operates within the interval (0, ± 3). This index allows us to quantify the severity of each event, with positive values indicating excess water due to flooding and negative values representing deficits due to drought.

RESULTS AND ASSESSMENT

In our analysis of historical documentation, we aim to uncover the climatic patterns and their effects on Seville throughout the 18th century. We examine the impacts of both river floods and periods of drought separately. Seville's location on a flood plain necessitated the maintenance of medieval walls to help mitigate

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recurring river overflows. The river's low course, slight slope, and meandering path made evacuating water very challenging. We describe the construction of defensive systems and the consolidation and upkeep of the barrier walls. We detail the impacts of major floods in 1708, 1758, 1777, 1784, and 1796, which resulted in loss of life, property damage, and significant negative economic and social impacts. Analysis of historical records reveals that flooding within the city was primarily caused by damming of accumulated rainwater, caused by the forced closure of the of the drainage system to prevent additional outside water from entering, then the subsequent release of gates due to the overflow pressure of the water, and seepage through groundwater and walls due to the level of the floods. Conditions were even more dire in the less protected suburbs and riverside towns. We also outline the effects of prolonged droughts, including crop loss leading to shortages and social conflict. This analysis enabled us to develop a chronological understanding of water risk during the 18th century. We observe an initial phase with a higher flood risk, followed by fluctuating periods indicative of drought risk, particularly between 1734-38 and 1750-54. Recent decades have seen increased risk due to excess water.

DISCUSSION

In our discussion, we note that the southwest region of the Iberian Peninsula exhibits a relatively consistent climate, with buffered spatial variability. Our findings align with those of other researchers who have studied similar geographical areas, such as the south of Portugal and neighboring regions like Tierra de Barros and the Duchy of Feria in Extremadura. These researchers have employed different sources and methodologies, yet their results corroborate our own observations.

CONCLUSIONS

Our analysis focuses on three main elements influencing Seville's vulnerability during the 18th century: extreme weather phenomena, their impact on the population, and the defense mechanisms in place to prevent and mitigate them. Our discussion is structured around the recurring effects of river floods in the city and surrounding plains, as well as agricultural droughts during times of the area's climatic irregularities. We believe that our multidisciplinary analysis offers a novel perspective on the interaction of the climatic and hydrological elements, and their interconnection with the urban, economic, and social elements. Our analysis provides new insights into how these hydroclimatic events had an impact on the historical development of Seville during the 18th century.

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